PART I - ADMINISTRATIVE

Section 1. General administrative information

Title of project

Identification of larval Pacific lampreys (*Lampetra tridentata*), river lampreys (*L. ayresi*), and western brook lampreys (*L. richardsoni*) and thermal requirements of early life history stages of lampreys.

BPA project number	20065
Contract renewal date (mm/yyyy)	
Multiple actions? (indicate Yes or No)	

Business name of agency, institution or organization requesting funding

United States Geological Survey
Biological Resources Division
Columbia River Research Laboratory

Business acronym (if appropriate)	USGS CRRL

Proposal contact person or principal investigator:

Name	James G. Seelye
Mailing address	5501a Cook-Underwood Rd
City, ST Zip	Cook, WA 98605
Phone	509 538 2299
Fax	509 538 2843
Email address	jim_seelye@usgs.gov

NPPC Program Measure Number(s) which this project addresses

7.5F, 7.5F.1, and from the report resulting from 7.5F.1: Status report of the Pacific lamprey (*Lampetra tridentata*) in the Columbia River basin (BPA Project Number 94-026), Section III - Recommended Research, Subsections A, B, and C (abundance studies, current distribution, and other habitat limiting factors, respectively).

FWS/NMFS Biological Opinion Number(s) which this project addresses

Other planning document references

Identified as a research need at the Columbia Basin Pacific Lamprey Workshop, October 1998.

Short description

Determine characteristics that differentiate sympatric larval lamprey and evaluate thermal tolerances of larval lamprey by species

Target species

Pacific lamprey (*Lampetra tridentata*); western brook lamprey (*L. richardsoni*); river lamprey (*L. ayresi*)

Section 2. Sorting and evaluation

Subbasin

Evaluation Process Sort

CBFWA caucus		CBFWA eval. process		ISRP project type	
X one or more caucus		If your project fits either of these processes, X one or both		X one or more categories	
X	Anadromous fish		Multi-year (milestone-based		Watershed councils/model

			evaluation)		watersheds
X	Resident Fish		Watershed project eval.		Information dissemination
	Wildlife				Operation & maintenance
					New construction
				X	Research & monitoring
					Implementation & mgmt
					Wildlife habitat acquisitions

Section 3. Relationships to other Bonneville projects

Umbrella / sub-proposal relationships. List umbrella project first.

Project #	Project title/description
	Lamprey Research Projects
20064	Upstream Migration of Pacific Lampreys in John Day River

Other dependent or critically-related projects

Project #	Project title/description	Nature of relationship
9402600	Pacific Lamprey Research and Restoration	Project # 9402600 will provide specimens (ammocoetes).
Proposed by USFWS	Conduct Baseline Habitat and Population Dynamics Studies on Lampreys in Cedar Creek, WA	This project will provide specimens (mature adults and ammocoetes).
Proposed by IDFG	Evaluate Status of Pacific Lamprey in the Clearwater River Drainage, Idaho	This project will provide specimens (ammocoetes).

Section 4. Objectives, tasks and schedules

Past accomplishments

Year	Accomplishment	Met biological objectives?

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Determine diagnostic characteristics of egg and larval stages of lampreys	a	Spawn adult Pacific, river, and western brook lamprey in the laboratory, collect a time series of resulting progeny, and conduct morphometric analysis to determine diagnostic characteristics that differentiate these species
		b	Collect large ammocoetes from a variety of locations in the Columbia River Basin,

Obj 1,2,3	Objective	Task a,b,c	Task
			tentatively identify them, and hold them in the laboratory until metamorphosis to verify identification techniques
2	Evaluate temperature effects on the survival and early development of lampreys	a	Rear early life history stages of each species at four temperatures, document survival and timing of developmental events

Objective schedules and costs

Obj #	Start date mm/yyyy	End date mm/yyyy	Measureable biological objective(s)	Milestone	FY2000 Cost %
1	01/2000	09/2002	Diagnostic key to egg and early life stages		50
2	01/2000	09/2002	Criteria to assess critical habitat needs of early life history stages		50
				Total	100

Schedule constraints
Spawning of all three species may take more than one year if we have difficulty collecting mature adults of each species.
Completion date
September 2002

Section 5. Budget

FY99 project budget (BPA obligated):	$

FY2000 budget by line item

Item	Note	% of total	FY2000 ($)
Personnel		45.8	36,000
Fringe benefits		14.7	11,500
Supplies, materials, non-expendable property		12.0	9,500
Operations & maintenance			
Capital acquisitions or improvements (e.g. land, buildings, major equip.)			
NEPA costs			
Construction-related support			
PIT tags	# of tags:		
Travel			
Indirect costs		27.5	21,700
Subcontractor			
Other			
	TOTAL BPA REQUESTED BUDGET		78,700

Cost sharing

Organization	Item or service provided	% total project cost (incl. BPA)	Amount ($)
USGS CRRL	technical advice and supervision	9.7	10,000
USFWS CRFPO	Collection of adult specimens. Collection of ammocoetes. Technical assistance with ammocoete identification (Objective 1.b).	9.7	10,000
CTUIR	Collection of ammocoetes.	1.9	2,000
IDFG	Collection of ammocoetes.	1.9	2,000
		Total project cost (including BPA portion)	102,700

Outyear costs

	FY2001	FY02	FY03	FY04
Total budget	74,300	43,350		

Section 6. References

Watershed?	Reference
	Bond, C.E. 1994. Key to the freshwater fishes of Oregon. Oregon State University, Corvallis, OR.
	Beamish, R.J. 1980. Adult biology of the river lamprey (*Lampetra ayresi*) and the Pacific lamprey (*Lampetra tridentata*) from the Pacific coast of Canada. Canadian Journal of Fisheries and Aquatic Sciences 37:1906-1923.
	Beamish, R.J., and C.D. Levings. 1991. Abundance and freshwater migrations of the anadromous parasitic lamprey, *Lampetra tridentata*, in a tributary of the Fraser River, British Columbia. Canadian Journal of Fisheries and Aquatic Science 48:1250-1263.
	Bookstein, F.L., B. Chernoff, R.L. Elder, J.M. Humphries, G.R. Smith, and R.E. Strauss. 1985. Morphometrics in evolutionary biology. The Academy of Natural Science Philadelphia. Spec. Pub. No. 15, 277 pp.
	Close, D.A., M. Fitzpatrick, H. Li, B. Parker, D. Hatch, and G. James. 1995. Status report of the Pacific lamprey *(Lampetra tridentata)* in the Columbia Basin. Report (Contract 95BI39067) to Bonneville Power Administration, Portland, Oregon.
	Hammond, R.J. 1979. Larval biology of the Pacific lamprey, *Entosphenus tridentatus* (Gairdner), of the Potlach River, Idaho. M.S. thesis. University of Idaho, Moscow.
	Holmes, J.A. and P. Lin. 1994. Thermal niche of larval sea lamprey, *Petromyzon marinus*. Canadian Journal of Fisheries and Aquatic Sciences 51:253-262.
	Houde, E.D. 1987. Fish early life history dynamics and recruitment variability. American Fisheries Society Symposium 2, pp. 17-29.
	Jackson, A.D., P.D. Kissner, D.R. Hatch, D.A. Close, H. Li. 1997. Pacific lamprey research and restoration. 1996 Annual Report to Bonneville Power Administration (Contract Number 95BI39607).
	Kan, T.T. 1975. Systematics, variation, distribution, and biology of lampreys of the genus *Lampetra* in Oregon. PhD dissertation. Oregon State University, Corvallis, OR. 194 pp.
	Kendall, A.W., E.H. Ahlstrom, and H.G. Moser. 1984. In Ontogeny and systematics of fishes. Spec. Pub. No. 1. Am. Soc. of Ichthyologists and Herpetologists, Allen Press, Inc., Lawrence, KS.
	Northwest Power Planning Council. 1994. Columbia Basin Fish and Wildlife Program.

	Portland, OR.
	Piavis, G.W.1961. Embryological stages in the sea lamprey and effects of temperature on development. USFWS Fishery Bulletin. 61:111-143.
	Pletcher, F.T. 1963. The life history and distribution of lampreys in the Salmon and certain other rivers in British Columbia, Canada. M.S. thesis, University of British Columbia, Vancouver, B.C. 195 p.
	Potter, I.C., and F.W.H. Beamish. 1975. Lethal temperatures in four species of lampreys. Acta Zoologica 56:85-91.
	Quinn, T.P., and D.J. Adams. 1996. Environmental changes affecting the migratory timing of American shad and sockeye salmon. Ecology 77:1151-1162.
	Richards, J.E. 1980. The freshwater life history of the anadromous Pacific lamprey, *Lampetra tridentata*. M.S. thesis, University of Guelph, Guelph, Ont. 99 p.
	Richards, J.E., R.J. Beamish, and F.W.H. Beamish. 1982. Descriptions and keys for ammocoetes of lamprey from British Columbia, Canada. Canadian Journal of Fisheries and Aquatic Sciences 39:1484-1495.
	Sokal, R.R. and F.J. Rohlf. 1995. Biometry:the principles and practice of statistics in biological research. W.H. Freeman & Co. New York, NY.
	Smith, A.J., J.H. Howell, and G.W. Piavis. 1968. Comparative embryology of five species of lampreys of the upper Great Lakes. Copeia. 3:461-469.
	Young, R.J., J.R.M. Kelso, and J.G. Weise. 1990. Occurrence, relative abundance, and size of landlocked sea lamprey (*Petromyzon marinus*) ammocoetes in relation to stream characteristics in the Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences 47:1773-1778.
	Youson, J.H., J.A. Holmes, J.A. Guchardi, J.G. Seelye, R.E. Beaver, J.E. Gersmehl, S.A. Sower, and F.W.H. Beamish. 1993. Importance of condition factor and the influence of water temperature ond photoperiod on metamorphosis of sea lamprey, *Petromyzon marinus*. Canadian Journal of Fisheries and Aquatic Sciences 50:2448-2456.

PART II - NARRATIVE

Section 7. Abstract

Pacific lampreys (*Lampetra tridentata*) in the Columbia River Basin are believed to have declined to only a remnant of their population prior to hydropower development in the Columbia River Basin. Rehabilitation is being considered in some areas where lampreys are believed to have been extirpated. Status of sympatric lamprey populations (western brook lamprey *L. richardsoni* and river lamprey *L. ayresi*) is unknown. Identification of biological and ecological factors limiting lampreys is critical to population assessment and recovery efforts. We propose to address two fundamental aspects of lamprey biology. First, we will describe diagnostic characters of egg and larval stages of Pacific, river, and western brook lampreys and prepare an identification key. Second, we will examine the effects of temperature on the timing of developmental events and on the survival of early life history stages of lampreys. Identification of biological and ecological factors limiting lampreys in the CRB is critical to population assessment and recovery efforts. Results of this work will provide important tools necessary to evaluate the status of Pacific lampreys and assist with rehabilitation efforts.

Section 8. Project description

a. Technical and/or scientific background

The ecological, economic, and cultural significance of Pacific lampreys has been underestimated historically (Kan 1975; NPPC 1995; Close et al. 1995) and actions are currently being considered for their recovery in the Columbia River Basin (CRB) (Close et al. 1995). Identifying the biological and ecological factors that may limit lamprey production in the Columbia River Basin is critical for their recovery. Although some biological and ecological information for this and sympatric species (western brook lamprey *L. richardsoni* and river lamprey *L. ayresi*) is available from studies conducted in Canada (Pletcher 1963, Beamish 1980, Richards 1980, Beamish and Levings 1991), little is known about the biology and ecology of lampreys in the CRB (Kan 1975, Hammond 1979).

Identification of biological and ecological factors limiting lampreys in the CRB is critical to population assessment and recovery efforts. Understanding factors influencing survival during early life history stages is particularly important since this period is a critical determinant of recruitment to many fish populations (Houde 1987). Larval lamprey (ammocoete) abundance may be determined by water temperatures during early development or by other physical habitat characteristics (Potter and Beamish 1975, Young et al. 1990, Youson et al. 1993). For example, the range of optimal temperatures for survival of sea lamprey embryos is narrow (Piavis 1961).

Documenting the distribution and relative abundance of lampreys in streams and rivers tributary to the Columbia River will help identify factors limiting lamprey populations, identify areas in need of rehabilitation, and help to assess the efficacy of management actions. Surveys of lamprey ammocoetes may provide an effective means of determining distribution and abundance since ammocoetes are readily collected from rearing areas by electroshocking. However, our inability to identify ammocoetes of different lamprey species limits the utility of this technique. Identification of Pacific, river, and western brook lamprey ammocoetes is not resolved and characters currently used to differentiate species have proven to not be diagnostic (USGS unpublished data). Developing lamprey ammocoete identification techniques is critical to determine the distribution and abundance of these fishes.

Understanding how temperature affects survival and growth of early life history stages will help identify critical habitat needs that influence lamprey distribution and abundance (Holmes and Lin 1994). Information on the role of temperature in larval lamprey development will provide managers with a means to assess suitability of available spawning and rearing habitats. Due to alterations in the temperature regime of the Columbia River and its tributaries as a result of hydroelectric and other development (Quinn and Adams 1996), lamprey spawning and rearing habitats may be suboptimal today.

Knowledge of the early life history characteristics of these species will aid in future research and management of lampreys in the Columbia Basin. Accurate identification of ammocoetes will allow managers to conduct larval surveys and thus determine the relative abundance of each species in various habitats. Presence or absence of Pacific lampreys in a given stream will play a key role in lamprey rehabilitation by identifying optimal habitats and locating areas suitable for recovery efforts.

This work will answer questions about Pacific lampreys posed by regional fishery managers. Specifically, population assessment and the quantification of habitat needs will help managers in developing strategies to assure the long-term population stability of Pacific lampreys and reduce the likelihood that the management of this species will be handled through the regulatory process.

b. Rationale and significance to Regional Programs

Sections 7.5F and 7.5F.1 of the NPPC Fish and Wildlife Program (1994) noted the apparent decline of Pacific lamprey in the CRB, and requested a status report that would identify research needs. Section three of the resulting report (Close et al. 1995) outlines these research needs (in part): section III.A, abundance studies; section III.B, current distribution; and, section III.D, determine habitat limiting factors. Close et al. (1995) also list the "identification of potential applications of transplantation" and "…artificial production" (section III.E and section III.F) as research needs.

Findings will provide tools for regional fisheries managers to assess lamprey populations and quantify habitat needs. This study will develop larval identification keys, which will allow differentiation of CRB lamprey ammocoetes. The ability to reliably identify lamprey ammocoetes will greatly facilitate the success of other studies of lampreys in the CRB. Examination of temperature effects will contribute to the determination of habitat limiting factors that influence lamprey distribution and abundance.

c. Relationships to other projects

This project will rely on the USFWS for assistance collecting mature adults for spawning (Objective 1.a) and ammocoetes for rearing through metamorphosis (Objective 1.b). The CTUIR (Project #9402600) and IDFG have also agreed to supply ammocoetes for Objective 1.b. We believe this information will contribute to the success and utility of other lamprey research in the CRB.

d. Project history (for ongoing projects)

e. Proposal objectives

1. Determine diagnostic characteristics of egg and larval stages of Pacific, river, and western brook lampreys.

2. Examine the effects of temperature on the timing of developmental events and on the survival of early life history stages of Pacific, river, and western brook lampreys.

f. Methods

Objective 1.
Task a. For morphometric examinations, adult Pacific, river, and western brook lampreys will be collected from the wild using fyke nets, traps, a backpack electroshocker, or by hand, and transported to the Columbia River Research Laboratory. Eggs from mature females will be fertilized as in Piavis (1961). Eggs will be incubated at 18°C in flow-through incubators (Macdonald jars). A developmental time series will be collected of the resulting progeny of each species, following sampling guidelines in Piavis (1961) and Smith et al. (1968). Conventional morphometric descriptions will be prepared as in Kendall et al. (1984). Morphometric differences between species will be examined using principal components analysis (Bookstein 1985).
Task b. Ammocoetes will be collected from other researchers in the CRB, including CTUIR, USFWS CRFPO, and IDFG, and transported to the CRRL. Ammocoetes will be held in flow-through aquaria at ambient temperatures under natural photoperiod and fed larval fish food. Ammocoetes will be examined monthly and biological characteristics will be recorded, including: species identification, length, weight, and metamorphosis stage. A photograph will be taken of each ammocoete. After metamorphosis, previous identification of ammocoetes will be evaluated.

Objective 2. To study the effects of temperature on the early development of lampreys, eggs and larvae will be incubated at four temperatures. Adults will be collected from the wild and eggs will be fertilized as in Piavis (1961). Eggs will be incubated for 18 hours, until successful fertilization can be determined. Fertilized eggs will randomly be assigned to each of four temperatures, with ten replicates of 100 eggs per temperature. Following hatch, prolarvae will be transferred to containers with sand to allow for burrowing. The percent survival to specific developmental stages (we will use stages as in Piavis 1961) will be compared for all temperatures using one-way ANOVA (Sokal and Rohlf 1995.) Observations on timing to developmental events will be made for eggs and larvae reared at each temperature. Abnormalities in embryos and larvae will be described and total number of obvious abnormalities will be compared between temperatures.

g. Facilities and equipment

The Columbia River Research Laboratory is equipped with many of the resources necessary to successfully complete this project. Laboratory and office space and equipment, including desktop computers and software are available. Adult lamprey will be collected from state and USFWS land, with the assistance of the USFWS Columbia River Fisheries Program Office, Vancouver, WA. Laboratory work will be conducted at the USGS BRD Columbia River Research Laboratory, Cook, WA. Some equipment is available, while some items will be purchased. We will make every effort to borrow equipment before making purchases.

h. Budget

This project may require two years to complete. The budget presented for FY 2000 covers three quarters. The budget for FY 2001 includes the last quarter of work required for the first year and three quarters of the second year. The budget for FY 2002 covers two quarters tp provide for completion of data analysis and report and manuscript preparation.

The budget for purchase of miscellaneous equipment may be reduced if we are able to borrow equipment from other researchers in the basin. We will make every effort to do so prior to making purchases.
The USGS will contribute $15,000 for technical advice and supervision as a cost-sharing opportunity.
Section 9. Key personnel

James G. Seelye--principal investigator for proposed work

Current Position: Supervisory Fishery Biologist, GS-14
Laboratory Director
Columbia River Research Laboratory
Cook-Underwood Road
Cook, Washington 98605

Education and Training:

Degree		Date	School
B.S.	Biological Science	1969	Lake Superior State College
M.S.	Limnology	1971	Michigan State University
Ph.D.	Limnology	1975	Michigan State University

Experience:

Research Limnologist, Project Manager, USACE, Waterways Experiment Station, 1975-1976
Supervisory Fishery Biologist (Research), Project Leader, FWS, Contaminant Dynamics, Great Lakes Fishery Laboratory, 1976-1982
Supervisory Fishery Biologist (Research), Station Chief, FWS, Hammond Bay Biological Station, 1982-1995
Supervisory Fishery Biologist, Director, USGS/BRD, Columbia River Research Laboratory, 1995 to present

Current Assignment: I am currently the Director at the CRRL, a major fishery research lab on the Columbia River. I have provided advice and assistance to lamprey researchers in the US and Canada for almost 20 years. Members of my staff and I are funded to conduct studies of the physiological effects of the fish bypass facilities at the Bonneville Dam. I provide advice and assistance to Dave Close with the CTUIR on their studies on a regular basis. I maintain a working relationship with the staff working on sea lampreys in the Great Lakes.

Selected Publications:

Seelye, J. G., L. L. Marking, E. L. King, Jr., L. H. Hanson, and T. D. Bills. 1987. Toxicity of TFM lampricide to early life stages of walleye. North American Journal of Fisheries Management 7:598-601.

Bergstedt, R. A., W. D. Swink, and J. G. Seelye. 1993. Evaluation of two locations for coded wire tags in larval and small parasitic-phase sea lampreys. North American Journal of Fisheries Management 13:609-6120.

Youson, Y. H., J. A. Holmes, J. A. Guchardi, J. G. Seelye, R. E. Beaver, J. E. Gersmehl, S. A. Sower, and F. W. H. Beamish. 1993. Importance of condition factor and the influence of water temperature and photoperiod on metamorphosis of sea lamprey, Petromyzon marinus. Canadian Journal of Fisheries and Aquatic Sciences 50:2448-2456.

Bergstedt, R. A., and J. G. Seelye. 1995. Evidence for lack of homing by sea lampreys. Transactions of the American Fisheries Society 124:235-239.

Fredricks, Kim T. and James G. Seelye. 1995. Flowing-recirculated water system for inducing spawning phase sea lampreys to spawn in the laboratory. Progressive Fish Culturist 57:297-301.

Jennifer M. Bayer Team Leader for proposed work
Current Position:
Cooperative Education Agreement Student (Fishery Biologist)
US Geological Survey/Biological Resources Division
Columbia River Research Laboratory, Cook, WA 98605
(509) 538-2299 ext 273 Jennifer_Bayer@usgs.gov

Education:

Portland State University M.S. Biology, in progress (to be completed Feb. 1999).
Oregon State University B.S. Fisheries Science,1993.

Experience:

1997-Present Cooperative Education Agreement Student, Columbia River Research Lab, Cook, WA & Portland State University, Portland, OR.
1994-1997 Fishery Biologist, USGS BRD Columbia River Research Laboratory.
1992-1994 Student Research Assistant, Stream Team, OSU, Corvallis, OR.
1991 Biological Technician, Northern Squawfish Predator Control Project, Dept. of Agricultural & Resource Economics, OSU, Corvallis, OR.
1990-1991 Work-study student, Oregon Cooperative Fishery Research Unit, OSU.
1989 Technician II, Normandeau Associates, Inc., Peekskill, NY.
1987-1988 Technician II, Prince William Sound Aquaculture Corporation, Cordova, AK.

Current Research Assignments:

I am currently working on several research projects involving lampreys. We will examine the swimming performance of adult Pacific lampreys and use electromyogram radiotelemetry to determine the effects of exhaustive stress in these fish. We are also presently examining morphometric characteristics of upstream migrating adult Pacific lampreys captured at Bonneville Dam. We are holding adult Pacific lampreys in our laboratory and intend to describe morphometric changes these fish undergo as they become sexually mature. I am also currently collaborating with the USFWS CRFPO on two projects: first, we are examining utility of PIT tags (survival and tag retention) in ammocoetes and recently metamorphosed lampreys; and second, we are evaluating reliability of ammocoete identification criteria by identifying and holding ammocoetes through metamorphosis.

I am near completion of the morphometric investigation early life history stages of native Columbia River cyprinids for a Master's in Science degree from Portland State University. For this project, I have conducted laboratory spawning and rearing of native cyprinids. Products of this work will be taxonomic descriptions of native cyprinid species and an identification key for early life history stages of Columbia River Basin cyprinids. I am developing a methodology for the use of video and digital image processing for description and identification of cyprinid larvae. I am also collaborating with researchers at the University of Idaho to examine phylogenetic relationships among native cyprinids through examination of mitochondrial dna.

Publications, reports, manuscripts, etc.:

Bayer, J.M. Morphometric investigation of early life history stages of Columbia River cyprinids. (Master's thesis in progress.)
Bayer, J.M. 1997. Use of image analysis for morphometric investigation of chiselmouth and northern squawfish larvae. Presentation to the American Fisheries Society, 21st Annual Larval Fish Conference, Seattle, WA.(chapter in thesis.)

Travis C. Coley, will provide technical assistance for proposed work

Present Position: U.S. Fish and Wildlife Service
Columbia River Fisheries Program Office
9317 N. E. Highway 99, Suite I
Vancouver, WA 98665

Education and Training:

Degree	Date	School
B.S. Fisheries Management	1976	Mississippi State University
M.S. Fisheries Resources	1979	University of Idaho

Experience:

1991-present Team leader, Habitat and Natural Production Team, Columbia River Fisheries Program Office Supervises a staff of 12 biologists and technicians working primarily on habitat assessment, habitat restoration, and fish population assessment and monitoring,

1986-1991 Assistant Project Leader of the Idaho Fisheries Resources Office, U. S. Fish and Wildlife Service, Ahsahka, Idaho.

1978-1986 Northwest and Alaska Fisheries Center, National Marine Fisheries Service, Hammond, OR

Pertinent Reports and Publications:

Durkin, J.T., T.C. Coley, K.J. Verner, and R.L. Emmett. 1981. An evaluation of aquatic life found at four hydraulic scour sites in the Columbia River estuary elected for potential sediment disposition. Proceedings of the National Symposium of Freshwater Inflow to Estuaries, USFWS, San Antonio, Texas. Vol. I: 436-452.

Muir, W.D., J.T. Durkin, T.C. Coley, and G.T. McCabe, Jr. 1985. Escapement of Dungeness crab, *Cancer magister*, from crab pots in an estuarine habitat. North American Journal of Fisheries Management 4:552-555.

Coley, T.C., G.T. McCabe, Jr., R.L. Emmett, and R.J. McConnell. 1986. Juvenile lingcod outer harbor field survey, Grays Harbor navigation improvement project. NOAA, NMFS, Northwest and Alaska Fisheries Center, Seattle, Washington. 43p.

McCabe, G.T., Jr., R.L. Emmett, T.C. Coley, and R.J. McConnell. 1987. Effect of a river dominated estuary on the prevalence of *Crinonemertes errans*, an egg predator of the Dungeness crab, *Cancer magister*. Fishery Bulletin 85:140-142.

McCabe, G.T., Jr., R.L. Emmett, T.C. Coley, and R.J. McConnell. 1988. Distribution, density, and size class structure of Dungeness crab in the river-dominated Columbia River estuary. Northwest Science 62(5):254-262.

Giorgi, A.E., G.A. Swan, W.S. Zaugg, T.C. Coley, and T.Y. Barila. 1988. Susceptibility of chinook salmon smolts to bypass systems at hydroelectric dams. North American Journal of Fisheries Management 8:25-29.

Muir, W.D., A.E. Giorgi, and T.C. Coley. 1994. Behavioral and physiological changes in yearling chinook salmon during hatchery residence and downstream migration. Aquaculture 127(69-82).

Muir, W.D. and T.C. Coley. 1996. Diet of yearling chinook salmon and feeding success during downstream migration in the Snake and Columbia Rivers. Northwest Science 70 (298-305).

Section 10. Information/technology transfer

Results from this study will be disseminated in the form of annual reports of research, peer-reviewed journal publications, and oral presentations and briefings. This information will be provided to biologists from organizations conducting studies on lampreys or proposing studies including, Oregon, Washington, and Idaho state agencies, Native American tribes, and the US Fish and Wildlife Service Lower Columbia River Fishery Resource Office, Vancouver, WA.

Congratulations!